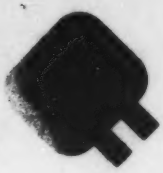

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EFFECTS OF COMPONENTS OF MACROBRACHIUM R. ENBERGII AQUACULTURE PRACTICE ' THEIR PRODUCTIVITY

Report No 84-458-K

Judith K. Kwik
Biologist
Biological Research Section

ABSTRACT

Components of Macrobrachium rosenbergii aquaculture practices in the tropics and semi-tropics were assessed for their effects on the production of this freshwater prawn. Variables investigated were related to substrate type, diet, shelter and surface area. The presence of a granular substrate, algae, and bottom formations in the form of bricks were assessed in terms of prawn survival and growth. Presence of sand with bricks resulted in significantly higher survival of the prawns while the availability of algae and to a lesser extent sand resulted in significantly higher weight gain.

job	file	date	report no.
740634-573-011	836.4	January 10, 1985	84-458-K

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EXECUTIVE SUMMARY

EFFECTS OF COMPONENTS OF MACROBRACHIUM ROSENBERGII AQUACULTURE PRACTICES ON THEIR PRODUCTIVITY

Judith K. Kwik
Biologist
Biological Research Section

In a review assessing the possibility of thermal aquaculture of crustaceans in a waste heat usage scheme the tropical freshwater prawn Macrobrachium rosenbergii was selected as worthy of further investigation on the basis of its culturability and market potential. As a first step variables which may impact on the success of aquaculture of this species were assessed for their effects on prawn production. In this study variables related to substrate type, diet, shelter and surface area were investigated. Combinations of a granular substrate, algae, and bottom formations in the form of bricks, were evaluated in terms of the survival and growth of the prawns.

The combination of sand and bricks increased the survival of the prawns significantly. It is postulated that crevices found in the sand under the bricks may have served as shelters resulting in the higher survival. The presence of algae and to a lesser extent sand resulted in significantly higher weight gain. Thus these components were found to contribute significantly to the production of the prawns.

During the course of this study it was demonstrated that Macrobrachium rosenbergii can be maintained for extended periods in existing laboratory facilities and first hand experience in handling the prawns was gained. However, the diet used did not result in satisfactory survival or growth.

job	file	date	report no.
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To Mr. F.J. Kee
Director of Research

EFFECTS OF COMPONENTS OF MACROBRACHIUM ROSENBERGII AQUACULTURE PRACTICES ON THEIR PRODUCTIVITY

J.K. Kwik

1.0 INTRODUCTION

The development of an economically feasible thermal aquaculture system for freshwater prawns could provide southern Ontario with a new industry that provides a product which commands a premium price and which is presently imported. Such a thermal aquaculture system could result in the use of waste heat from generating stations as well as electricity.

In a review assessing the possibility of thermal aquaculture of crustaceans in a waste heat usage scheme the tropical freshwater prawn Macrobrachium rosenbergii was selected as worthy of further investigation on the basis of its culturability and market potential (Ontario Hydro Research Division Report No. 84-56-K). This species is considered attractive for aquaculture because it will mature and reproduce readily in captivity throughout the year (Sandifer and Smith 1978). It is also hardy and omnivorous, and grows rapidly to a large size. In Hawaii where M. rosenbergii is cultured commercially, prawns of average market weight (45.6 g) can be harvested seven to nine months following stocking of postlarvae into growout ponds (Malecha 1980). The average yield in Hawaii is approximately 3322 kg/ha/yr (Malecha 1980). Their wholesale price in 1980 was approximately $10.00/kg and the retail price ranged from $14.30 to $15.40/kg (Malecha 1980). During the last five years the Hawaiian market absorbed between 250,000 and 320,000 pounds of these prawns (personal communication K. Lee).

Since environmental conditions in southern Ontario are considerably different from the tropics, direct transfer of existing culture practices to this area is not practical and the technology suitable for southern Ontario will have to be developed.

As a first step variables which were considered as potentially having an impact on the success of aquaculture of this species were chosen for investigation. Positive variables can then be taken into account in the development of a thermal culture system. In the present study components related to substrate type, diet, shelter and surface area were examined.

The features assessed were a granular substrate, algae and bottom formation. Most commercial ponds used for growout are earthen ponds containing natural soil microbial fauna. Algae is provided in larval rearing tanks (Malecha 1980) and is a natural occurring phenomenon in the growout ponds (Corbin et al no date) but has not been incorporated into tank cultures for nursery or growout phases. In a pond, rocks or stones provide bottom formations which may allow for separation of the often aggressive epibenthic animals providing shelter as well as increasing substrate surface area.

Thus our objective was to assess the effects of components of prawn culture practices on their growth and survival and thereby identify variables that can be incorporated into an intensive thermal aquaculture system to maximize production. Since this was our first attempt at working with Macrobrachium rosenbergii it also served to gain experience in maintaining the prawns for extended periods and to familiarize ourselves with the handling of these animals.

2.0 METHODS

The experimental setup consisted of a series of 36 white polyethylene tanks with dimensions of 58.4 X 48.3 X 40.6 cm (L X W X D) and bottom surface area of 0.28m^2. Twelve combinations of the three treatments, a granular substrate, algae, and bottom formations were setup as described in Table 1. A layer of sand (5 cm) was placed on the bottom of the tank to provide a granular substrate and bottom formations were created by placing three or six bricks (12 X 12 X 5.5 cm) on the bottom. The addition of three and six bricks increased the surface area of the culture tank to 0.37 and 0.45 m^2, respectively. Three replicates of 20 animals each were included per experimental condition.

A flow through system controlled the water circulation in the tanks. The temperatures in the tanks were controlled by adjusting the inflow rates of warm water to maintain target temperatures of 27 to 28 C. Mean monthly temperatures of the tanks, ranged from 26.5 to 29.2 C. The flow rate of warm water entering the tanks generally ranged from 3.6 to 7.2 L/h. Volume capacity of the tanks was 90 L. The tanks were aerated continuously which also served to keep the water destratified. Tanks were cleaned weekly by siphoning debris off the bottom and brushing the sides.

Tanks requiring algae were inoculated daily with 400 ml of a densely growing culture of Chlorella pyrenoidosa (4 x 10^{10}

Table 1

EXPERIMENTAL CONDITIONS

Substrate	Algae	Bottom Formation (Surface Area)
No sand	(A) Algae	No bricks (0.28 m^2) 3 bricks (0.37 m^2) 6 bricks (0.45 m^2)
	(B) No Algae	No bricks (0.28 m^2) 3 bricks (0.37 m^2) 6 bricks (0.45 m^2)
Sand	(C) Algae	No bricks (0.28 m^2) 3 bricks (0.37 m^2) 6 bricks (0.45 m^2)
	(D) No Algae	No bricks (0.28 m^2) 3 bricks (0.37 m^2) 6 bricks (0.45 m^2)

cells/L). The algal culture method used has been described in Ontario Hydro Research Division Report No. 83-383-K. The algal density in the tanks immediately following inoculation was approximately 4.4 X 10^8 cells/L.

The prawns were obtained from Amorient Aquafarms, Inc. of Kahuku, Hawaii. The average weight of the prawns at the start of the experiment ranged from 0.026 to 0.037 g (21 days postlarvae).

The prawns were fed once a day on a diet of Masterfeeds Chick Starter (79% by weight) to which the amino acids (1%) arginine, phenylalanine, leucine and isoleucine had been added and was bound by agar (10%) and gelatin (10%). The mixture was passed through a food extruder, pelletized and oven dried at 50 C. The protein content of the feed was approximately 24%.

The animals were counted and weighed (wet weight) weekly for the first eight weeks and biweekly for the remainder of the four month study period. Prawns from the same tank were weighed collectively on all occasions except at the termination of the experiment when individual weights were taken.

A model of exponential growth was developed to determine

differences in the survival and weight of the prawns raised under the various culture conditions. The model describes mean survival as a decreasing exponential function (r=0.93) of time and mean weight as an increasing exponential function (r=0.97) of time. The presence or absence of substrate, algae and the number of bricks were incorporated as dummy variables. The formula derived is as follows:

$$\ln s(\text{or } w) = B_o + B_a X_a + B_s X_s + B_3 X_3 + B_6 X_6 + B_t t + B_{t^2} t^2, \quad t>0$$

In the model, s is the mean survival (or in the case of the weight model, w is mean weight) and B_o is an intercept. X_a, X_s, X_3 and X_6 are dummy variables indicating the presence or absence of algae, substrate, 3 and 6 bricks, respectively. $B_t t$ describes the linear component of the growth (or survival) over time and $B_{t^2} t^2$, the second order component. The coefficients of the model were obtained by least squares estimation. The coefficients were tested for significance using a F test (P=0.05) to determine whether the presence of algae, substrate and bricks affected the survival or weight of the prawns.

3.0 RESULTS

The mean number of survivors (three replicates) were plotted according to the available substrate (the number of bricks present) under each experimental condition (Figures 1, 2, 3, and 4). Generally, the mortality rate was relatively low in the first four weeks, increased between weeks 4 and 12, and decreased between weeks 12 and 18. The densities in the tanks at the termination of the experiment ranged from a mean of 2.4 to 5.9/m^2 in the bare tanks and from 3.6 to 8.9/m^2 in the tanks with sand.

The survival plots for prawns in the bare tanks (Figures 1 and 2, A and B tanks) indicated that in the absence of sand the presence of bricks did not result in obvious increased survival over most of the experimental period. In the bare tanks with 0, 3 and 6 bricks, the mean survival at the end of the experiment was 1.14, 1.80, and 2.00, respectively. With a sand substrate (Figures 3 and 4, C and D tanks) a larger and more obvious increase in survival was obtained when bricks were provided. Subsequent to the first two weeks of experimentation the survival in the C and D tanks was lowest in the tanks without bricks and highest in those with 6 bricks. Mean survival at the end of the experiment for all tanks with sand and 0, 3 and 6 bricks was 1.40, 2.33, and 3.67, respectively.

A significant interaction effect of sand and bricks (Table 2, P=0.05) on the survival of the prawns indicated that the two variables were not independent.

Maximum mean survival in a set of replicate tanks at the termination of the experiment was 4.0 for the tanks with algae, a

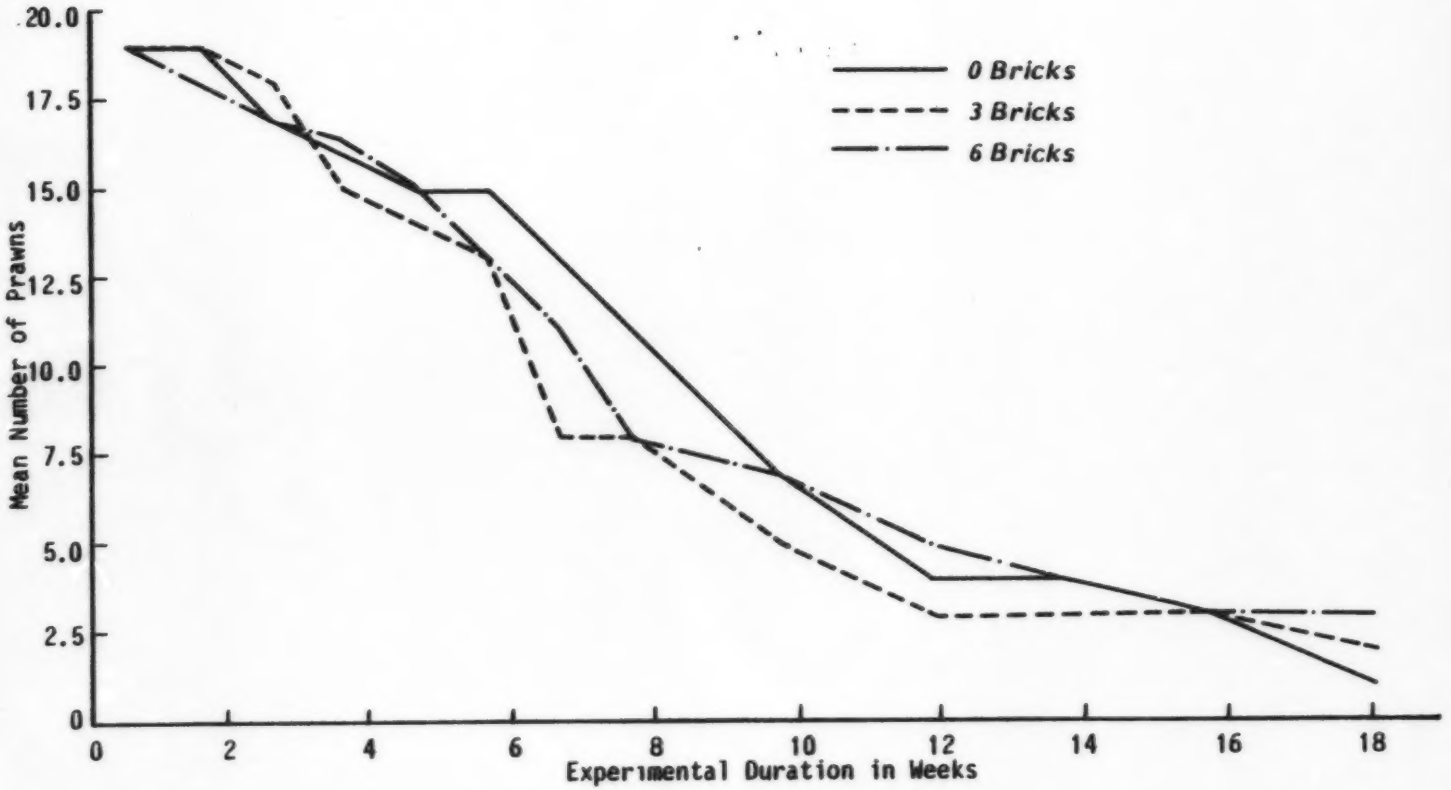

FIGURE 1

MEAN NUMBER OF SURVIVORS OVER EXPERIMENTAL DURATION IN A TANKS (BARE TANKS, WITH ALGAE) WITH 0, 3 AND 6 BRICKS

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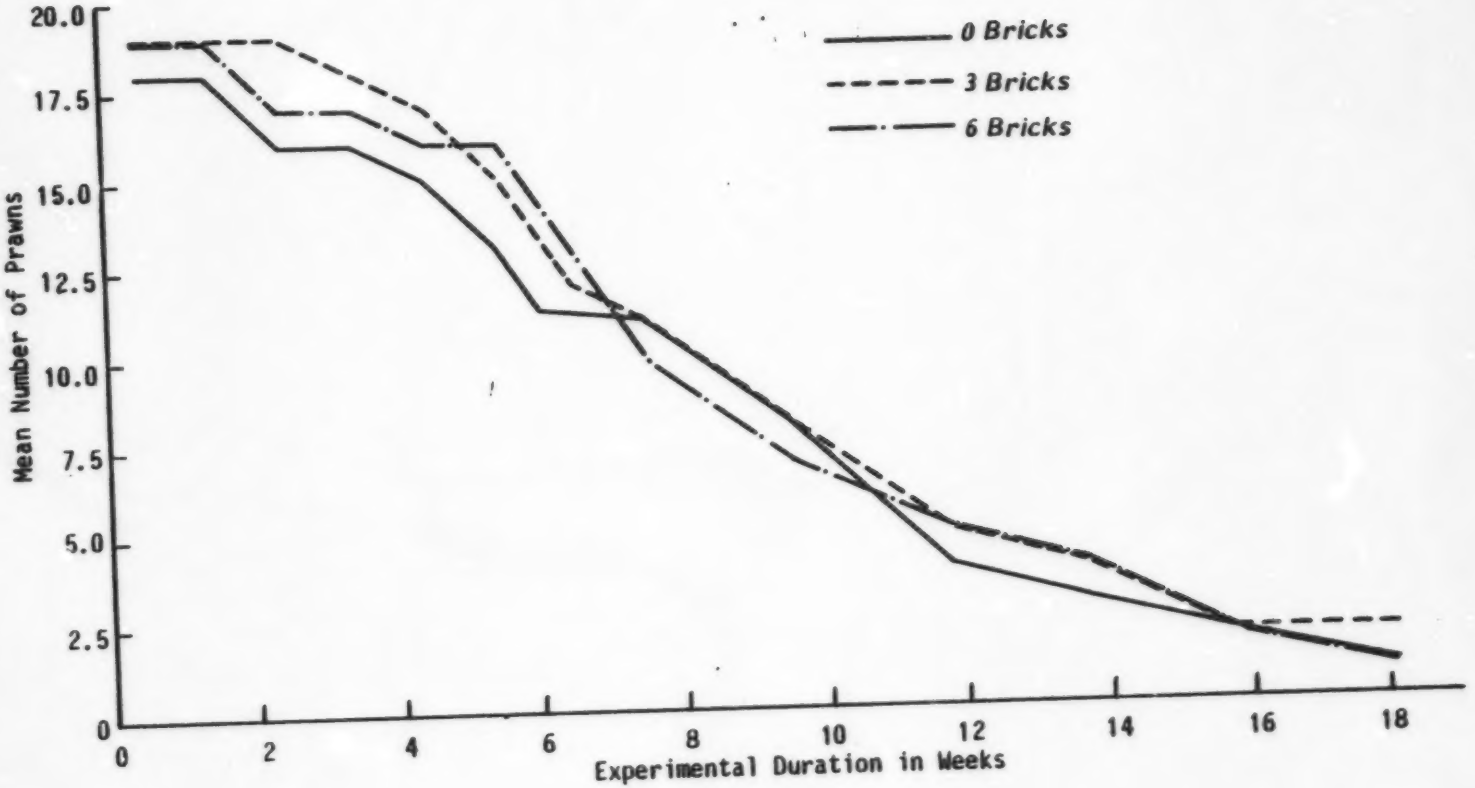

FIGURE 2

MEAN NUMBER OF SURVIVORS OVER EXPERIMENTAL DURATION IN 8 TANKS (BARE TANKS, WITHOUT ALGAE) WITH 0, 3 AND 6 BRICKS

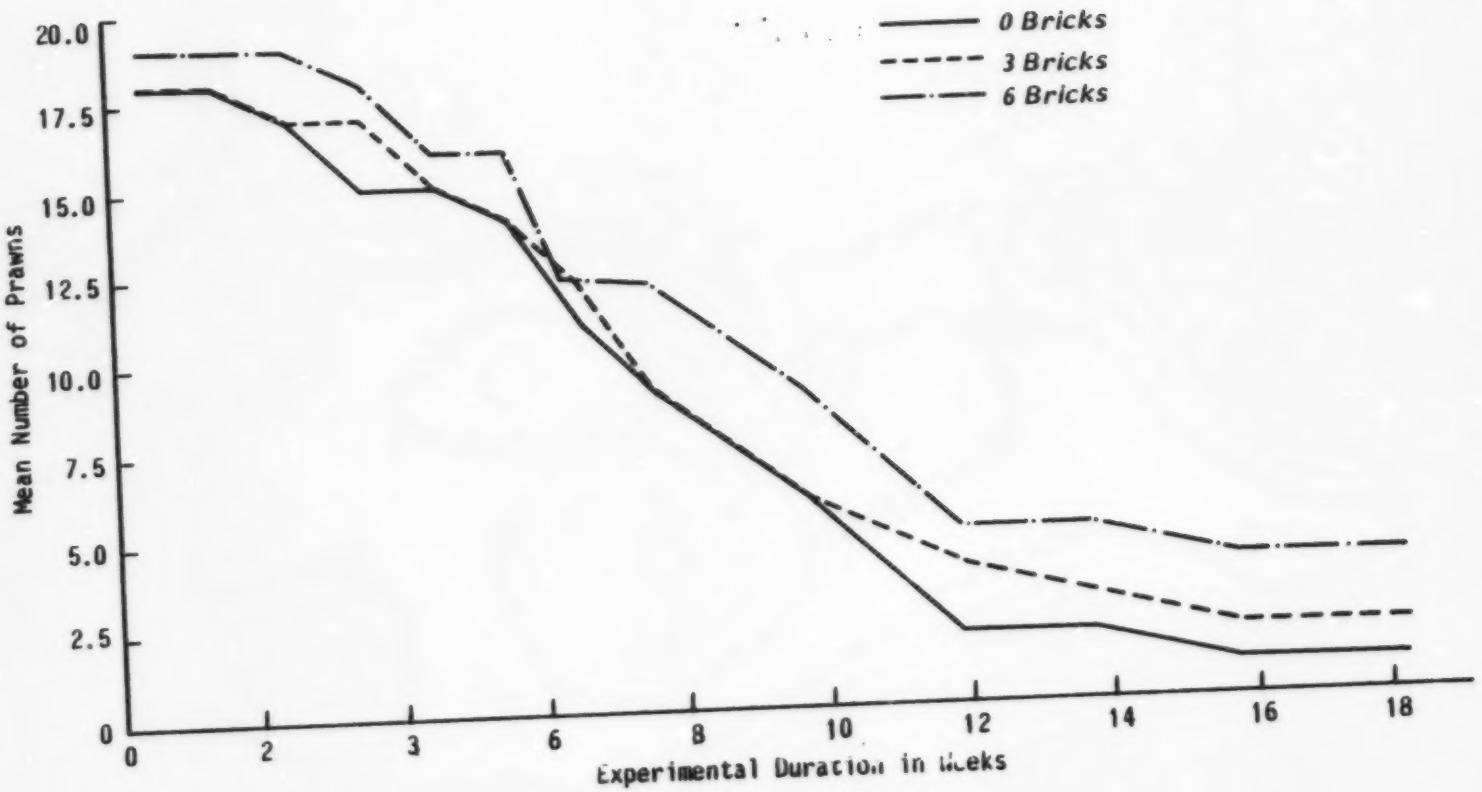

FIGURE 3

MEAN NUMBER OF SURVIVORS OVER EXPERIMENTAL DURATION IN C TANKS (SAND SUBSTRATE, WITH ALGAE) WITH 0, 3 AND 6 BRICKS

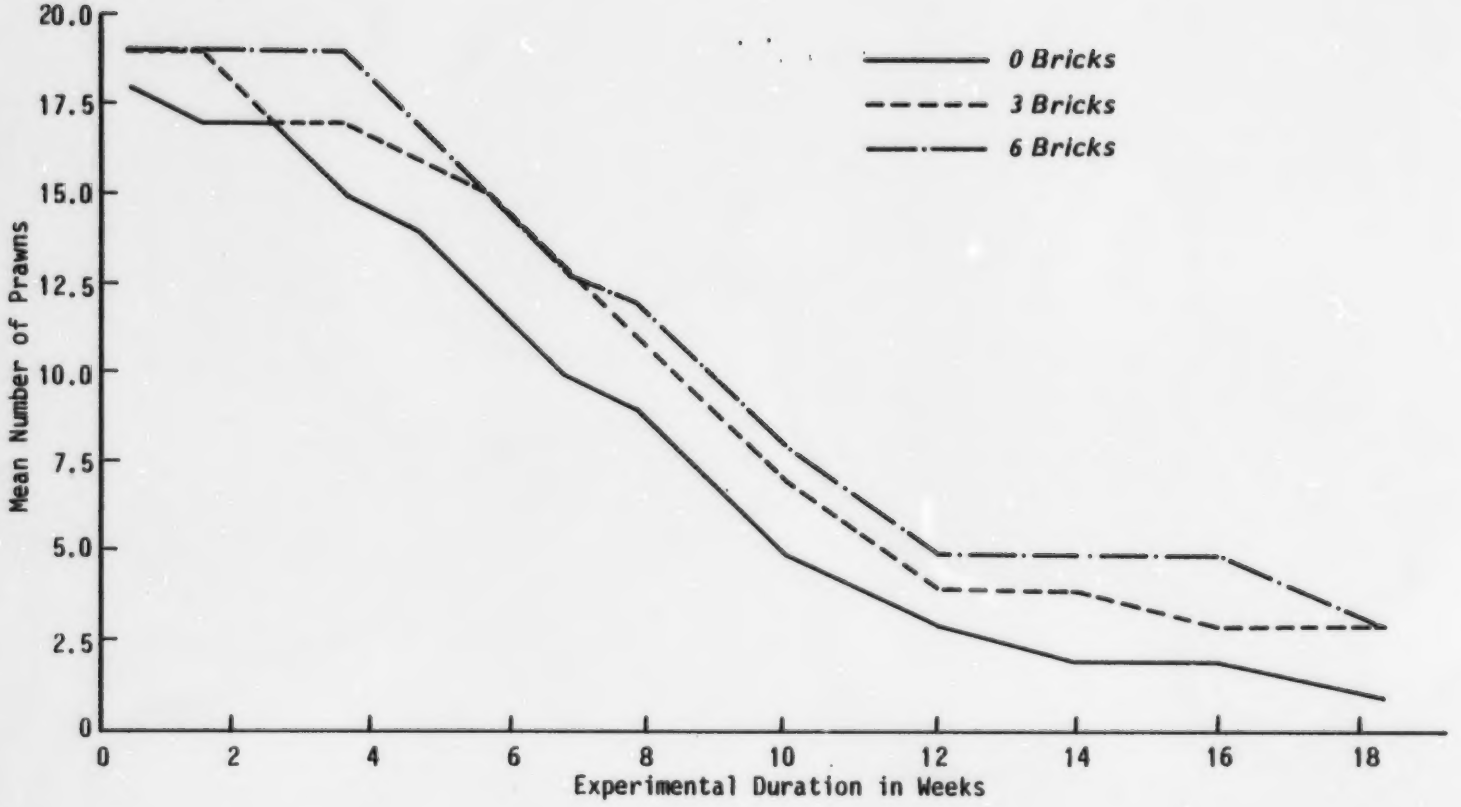

FIGURE 4

MEAN NUMBER OF SURVIVORS OVER EXPERIMENTAL DURATION IN D TANKS (SAND SUBSTRATE, WITHOUT ALGAE) WITH 0, 3 AND 6 BRICKS

TABLE 2

F Test - MEAN SURVIVAL

Source	DF	Sum of Squares	Mean Square	F Value	PR>F	R-Square	C.V.
Model	8	102.4305	12.8038	300.38	0.0001	0.9424	9.6388
Error	147	6.2659	0.0426		ROOT MSE		LAVGN MEAN
Corrected total	155	108.6964			0.2065		2.1419
XA		1	0.0186		0.44	0.5102	
XS		1	0.3264		7.66	0.0064	
X3		1	0.0055		0.13	0.7199	
X6		1	0.0432		1.01	0.3155	
XS3		1	0.2500		5.86	0.0167	
XS6		1	0.7565		17.75	0.0001	
Time		1	0.4088		9.59	0.0023	
Time Square		1	8.5718		201.10	0.0001	

TABLE 3

F Test - MEAN WEIGHT

Source	DF	Sum of Squares	Mean Square	F Value	PR>F	R-Square	C.V.
Model	7	147.9359	21.1366	699.39	0.0001	0.9706	9.8774
Error	148	4.4728	0.0302		ROOT MSE		LAVGN MEAN
Corrected total	155	152.4287			0.1738		-1.7600
XA		1	3.9127		129.47	0.0001	
XS		1	0.1623		5.37	0.0218	
X3		1	0.0064		0.21	0.6472	
X6		1	0.0063		0.21	0.6479	
XS6		1	0.0461		1.53	0.2186	
Time		1	4.6927		155.28	0.0001	
TimeSquare		1	0.3735		12.36	0.0006	

sand substrate and six bricks (C tanks) followed by 3.3 for the tanks with no algae, sand and six bricks (D tanks).

The mean weights (three replicates) of the prawns in the tanks were plotted according to tank type for tanks with 0, 3 or 6 bricks (Figures 5, 6 and 7, respectively). The growth rate of the animals was generally slowest during the first 8 weeks. A slight increase in the growth rate between weeks 8 and 16 was followed by a sharp increase in the last two weeks of the study.

The mean weights of the animals in the tanks with algae (A and C) were higher than in the corresponding tanks without algae (B and D) over most of the experimental period. Apparent declines in the mean weights of the animals in the culture tanks between sampling intervals were due to mortality of larger individuals. The mean weights of the prawns in the A and C tanks at the end of the experiment were 0.94 and 1.48 g, respectively, and in the B and D tanks they were 0.42 and 0.70 g.

Although not as consistent as the effect of algae, the presence of a sand substrate also resulted in higher weight gain with the mean weight of the prawns in the C tanks being greater than those in the A tanks and those in the D tanks weighing more than those in the B tanks.

Both algae and sand had significant effects (Table 3, $P=0.05$) on mean weight.

Maximum mean weight of 1.59 g was attained in the tanks that had algae and a sand substrate with 3 bricks. The size variability among animals grown in the same tank was substantial with four to five fold differences between the smallest and largest individual being common in the C and D tanks. In the tank where the largest difference was found the weights of the two prawns left at the termination of the experiment were 0.47 and 2.46 g. The largest individual weighed 2.68 g and was in one of the C tanks without bricks.

4.0 DISCUSSION

In this study we were able to assess the effects of some of the components of existing practices on the production of *Macrobrachium rosenbergii*. In addition we demonstrated that we are capable of maintaining this freshwater prawn for extended periods in our laboratory facilities. This study also gave us an opportunity to familiarize ourselves with the handling of the prawns.

The results indicated that the addition of a sand substrate with bricks on it to a prawn culture tank resulted in increased survival. During the course of the experiment crevices were observed in the sand under the bricks which probably provided shelter for the prawns. Thus the provision of shelter may have resulted in the increased survival.

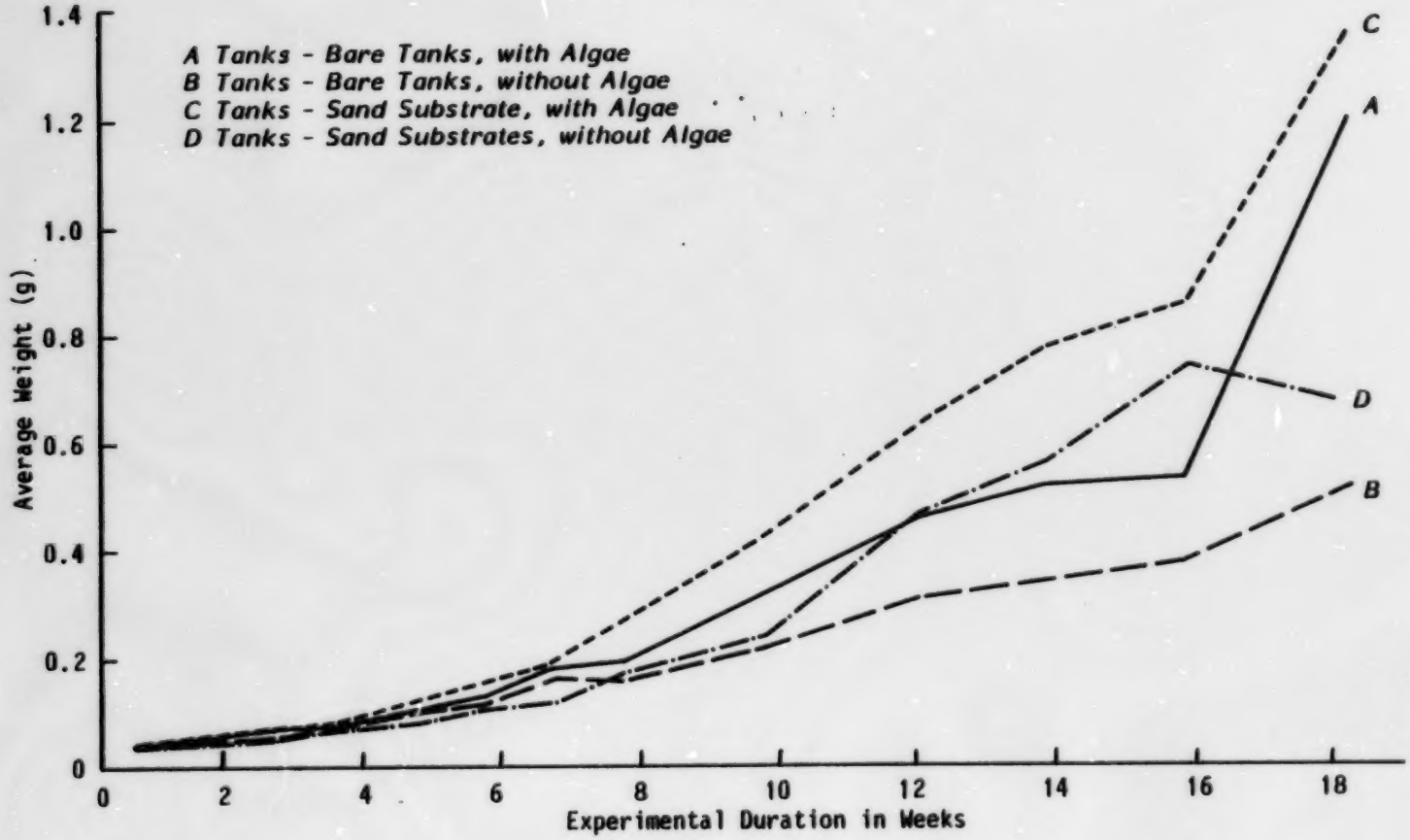

FIGURE 5

MEAN WEIGHT (g) OF PRAWNS IN A, B, C AND D TANKS WITH NO BRICKS OVER EXPERIMENTAL DURATION

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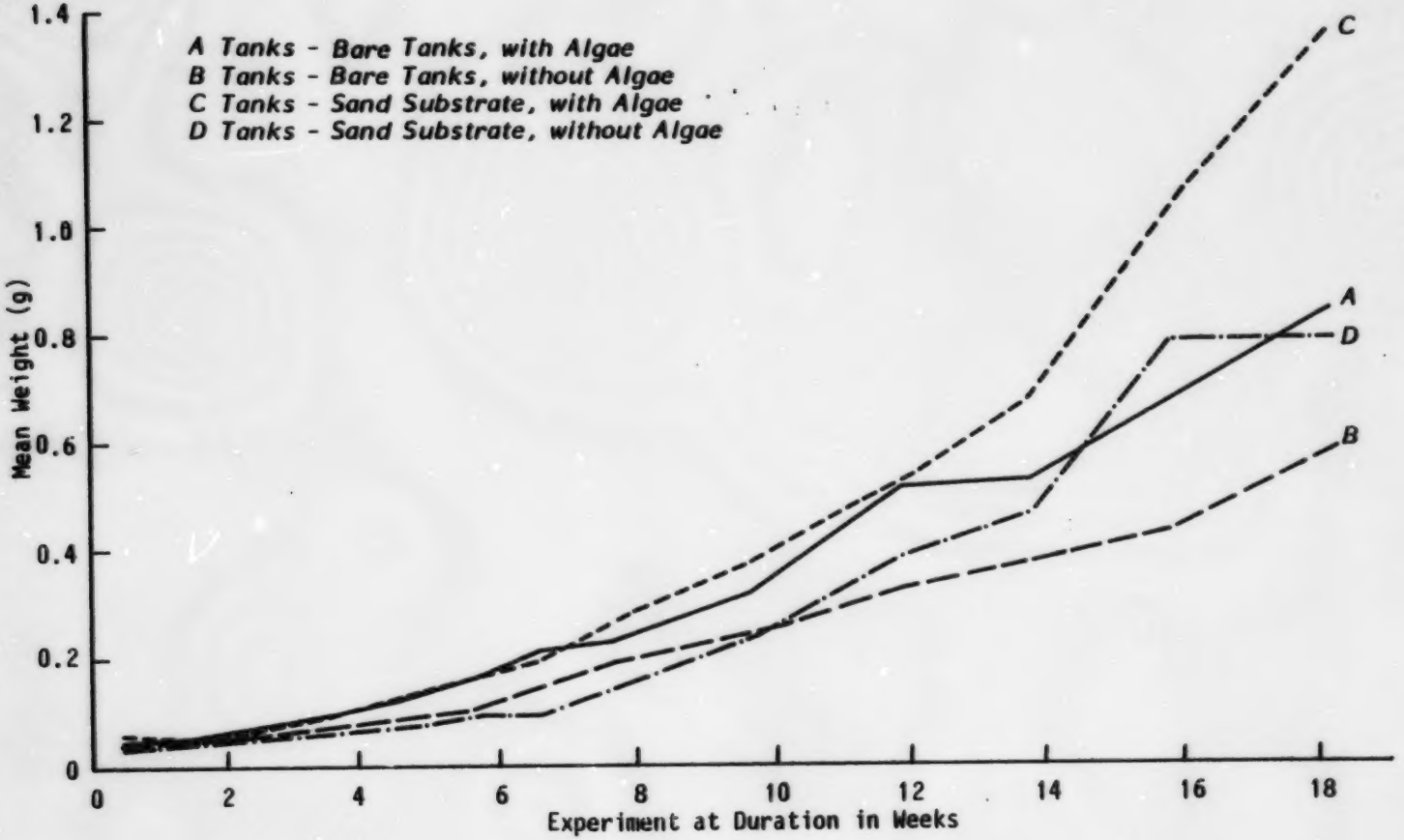

FIGURE 6

MEAN WEIGHT (g) OF PRAWNS IN A, B, C AND D TANKS
WITH 3 BRICKS OVER EXPERIMENTAL DURATION

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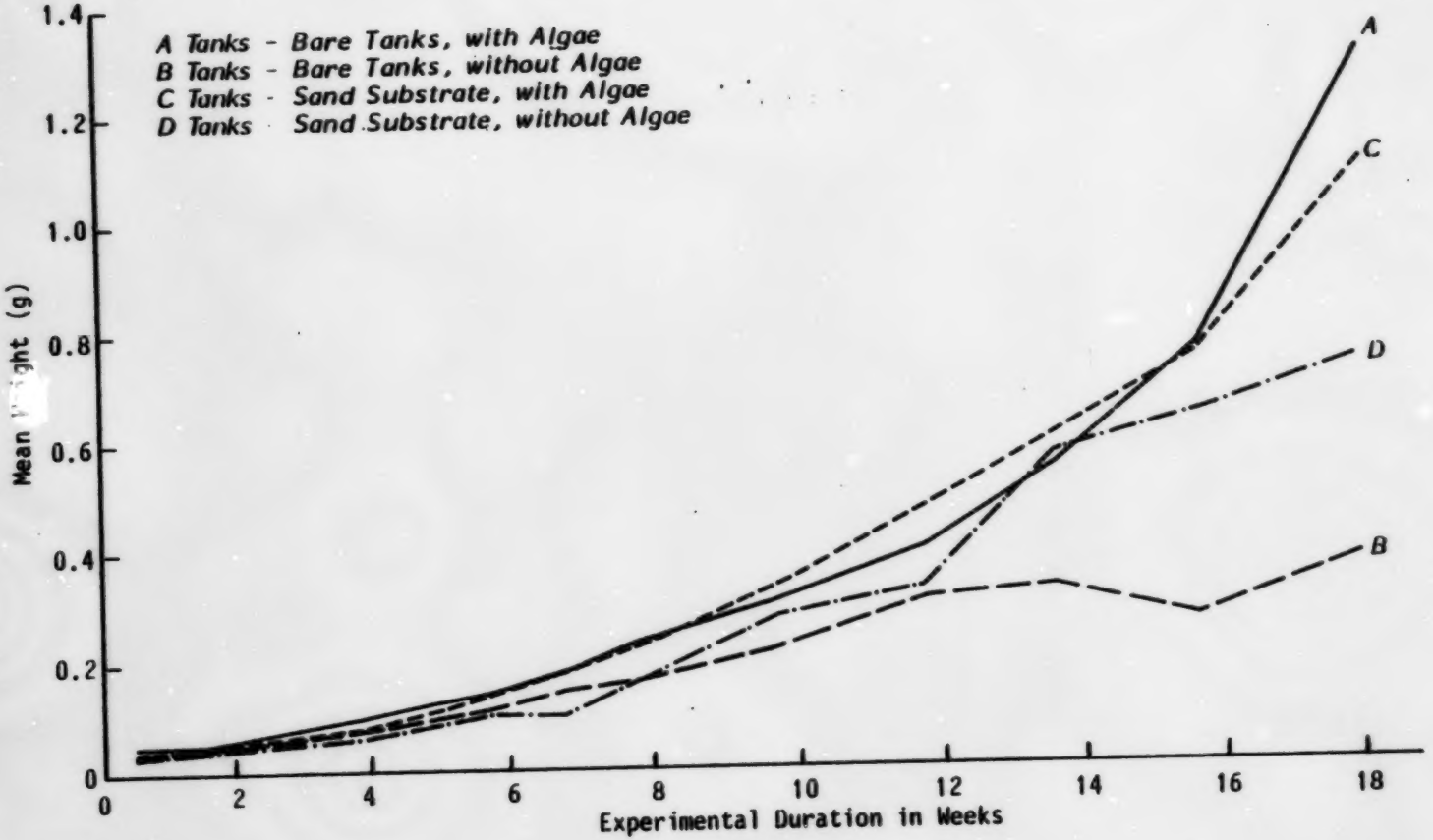

FIGURE 7

MEAN WEIGHT (g) OF PRAWNS IN A, B, C AND D TANKS
WITH 6 BRICKS OVER EXPERIMENTAL DURATION

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The bricks were added to the culture tanks in part to assess the effect of increased surface area as well as to provide visual breaks between animals. Although final survival was generally higher in the tanks with bricks than in those without bricks, the differences were not significant. Smith and Sandifer (1975) found that the addition of either horizontal or vertical substrates resulted in higher survival of the prawns. However, their stocking rate was considerably higher at 505/m^2 compared to our stocking rate of 71/m^2. The mean size of the animals in their experiment ranged from 0.8 to 3.8 g, which was larger than the mean size of our experimental animals. Thus increased surface area may be more important at higher densities and when dealing with larger animals than those used in our experiment.

The tanks that had the highest survival were also the tanks with the highest substrate surface area since the surface area of sand is higher than that of a bare tank. Although the spaces in a granular substrate are too small to be advantageous to the prawns in terms of spatial separation, the additional surface area gained may be of significance to microorganisms. The presence of this microbial fauna may create a favorable environment for the prawns. Thus the cumulative effects of the two aspects of surface area provided by the sand and bricks may have contributed to the higher survival observed.

The survival in all tanks was relatively poor. Maximum mean survival in a set of replicate tanks was only 25%. The low survival over the experimental period appears to have been in part due to mortality incurred during handling. To avoid capture the prawns would swim rapidly out of the nets often hitting the sides of the tank with considerable impact. Frequently during handling prawns jumped out of the tanks, nets, collection buckets or weighing dishes unto the floor or table top. Although recovery appeared immediate when the animals were returned to the tanks, dead prawns were most frequently observed on the first and second days following handling indicating latent post-handling mortality. For this reason the interval between data collections was increased from one to two weeks following the eighth week of experimentation.

Survival obtained in our study was not directly comparable to that reported by other researchers due to the differences in culture conditions. These differences included stocking densities, substrates, tank size and diet. Frequency of handling and the age of the animals used in the experiments also differed. Smith and Sandifer's (1975) data are reported here to give an indication of the level of survival that has been attained in tank cultures during the nursery stage. Using 1.8 m diameter, 2,200 l capacity tanks with horizontal substrates (frames covered with 0.50 m^2 fiberglas screening), vertical substrates and without any substrates the survival they obtained was 65, 54 and 32%, respectively, over a four-month study period. Smith and Sandifer had longer intervals (4 weeks) between measurements than we did avoiding excessive handling mortality. In the future we should limit handling of M. rosenbergii to a minimum of

monthly intervals.

The results of the present study indicated that the presence of algae resulted in greater weight gain of the prawns. Ling (1967) who described the general biology and development of Macrobrachium rosenbergii (de Man) and who is considered to be the father of the freshwater prawn business in the Americas (Chao 1979), lists algae among the common food items of this omnivorous prawn. Although he did not specify whether the algae consumed were filamentous or planktonic, ponds in Hawaii rich in specific assemblages of phytoplankton are considered to be good culture ponds. Thus the addition of algae to the culture system, possibly as a nutrient source for the prawns, during the first four months resulted in larger animals for further growout to adult size.

Our results also indicated that the presence of a sand substrate resulted in slightly higher weight gain. Quantitative and/or qualitative differences in the microbial fauna of a sand substrate compared to that of a bare tank may explain the difference in prawn weight. Stahl (1979) identified soil and detritus as some of the natural foods consumed by the prawns. In the tanks with sand substrate the detritus trapped in the sediment was available to the prawns as part of their diet. Any debris that built up in the bare tanks was siphoned off regularly such that the bacteria rich detritus was not available to the prawns in these tanks.

The growth rate of the animals was slowest in the initial 8 weeks of the experiment, increased slightly during the subsequent 8 weeks, and increased sharply during the final two weeks. This growth pattern is consistent with Manik's (1976) observation on Ling's (1967) growth data. Manik (1976) described their growth rate as being slow in the first three months and very rapid after the initial three months.

The large variation in size observed among animals cultured in common tanks is typical of this species (Malecha 1980). According to Segal and Roe (1975) the more aggressive prawns grow faster than the less aggressive individuals when they are maintained in groups. Ra'anan and Cohen (1984) compared body size of juveniles raised in groups and of those raised in isolation. They found a relative excess of size variation among animals raised in groups which was mainly associated with the appearance of exceptionally fast-growing animals termed "jumpers" and severely growth-repressed individuals termed "laggards".

The weight attained by the prawns at the end of the experimental period was low. Maximum mean weight obtained in a set of replicate tanks at the end of the four month period was 1.1 g. Hilton (1984) reported weight gain of prawns (initial weight 0.08 g) reared on seven different diets as ranging from 1.9 to 2.7 g in 12 weeks. Mancebo (1978) who investigated the growth of tank reared populations of M. rosenbergii obtained prawns of an average weight of 1.25 g and 1.16 g in 3028 and 18,927 l tanks,

respectively within a two month culture period.

The lack of weight gain of the prawns was probably due to a deficient diet (personal communication J.W. Hilton) which may also have contributed to the low survival. The protein content of our feed was only 24% compared to Hilton's (1984) diets which had a minimum protein content of 45%. Mancebo (1978) used a feed specially formulated for the prawns. Stahl (1979) observed significantly greater growth among prawns raised on a diet of both natural foods and commercial pellets (chick starter) than prawns raised on either natural foods or commercial pellets alone while prawns raised on natural foods alone achieved greater growth than those raised on commercial pellets alone. The specially formulated feeds used by Hilton (1984) and Mancebo (1978) probably provided the prawns with nutrients normally obtained from natural foods that may have been lacking from the diet fed to our prawns.

The deficient diet may have resulted in the exaggeration of the effects of algae and sand on the weight gain of the prawns. Thus the effects of algae and sand may not have been as significant if a nutritionally superior diet had been provided.

A comparative growth study using a variety of feeds should be conducted to determine whether the diet was limiting the weight gain and survival of the prawns during the course of this study and to identify a diet that will result in better survival and greater growth.

The results of this study demonstrate that the survival and growth of the prawns can be enhanced by manipulating the culture environment. With further development of variables that will enhance prawn survival and growth, a production level may eventually be attained that will render the commercial production of M. rosenbergii technically and economically viable in a waste heat usage scheme.

5.0 SUMMARY AND CONCLUSIONS

1. The addition of a sand substrate with bricks on it to the culture tanks resulted in increased survival of the prawns.

2. Algae, and to a lesser extent sand, resulted in significantly higher weight gain by the prawns.

3. The low survival and weight gain of the prawns were attributed to a deficient diet and a need to conduct a comparative diet study was identified.

4. In our first experience in working with Macrobrachium rosenbergii we have demonstrated that it is possible to maintain this freshwater prawn in our laboratory facilities for extended periods. In addition valuable first-hand experience in handling these animals was gained.

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